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RESULTS OF MAGNETIC CONTROL OF IRON IMPURITIES IN FELDSPAR

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It is shown that the empirical operating mass characteristic for magnetic control of iron impurities in feldspar plotted in semi-logarithmic coordinates contains a 'kink'. A variant is given for obtaining information about the actual mass fraction of iron impurities, taking account of the iron impurity not separated after a finite number of control operations.

Key words: iron impurity, magnetic control, operating mass characteristic.

Since iron impurities directly affect product quality, magnetic separation of raw materials is widely used in the production of glass and ceramic articles [1 – 3]. In addition, control of such impurities is important for evaluating the performance of magnetic separators.

The possibilities of one promising method of control — magnetic control — are shown in [4] for quartz glass. Variants of this method (for gypsum binders, talc and talcous magnesite, dolomite and chalk) are presented in GOST 23789–79, 25216–82, 23672–79 and 8253–79. Aside from performing the standard magnetic scanning of samples (a thin layer) of the medium, an important intermediate result of the improved method [4, 5] is a descending curve of the operating mass m of the separated iron impurities versus the ordinal number n of the operation $m = f(n)$.

For any finite number of operations this empirical characteristic, which goes to zero asymptotically, shows only the partial separation of iron impurities. Nonetheless, it can play the role of a base control characteristic tending toward an exponential function (this is clearly seen if the empirical operating mass characteristic is plotted in semi-logarithmic coordinates, in which it becomes linear):

$$m = A \exp(-kn), \tag{1}$$

where the empirical parameters A and k are specific to each individual operating mass characteristic.

Equation (1) makes it possible to obtain an exhaustive empirical working solution for the problem of magnetic control.

Indeed, written out term by term (for $n = 1, 2, 3, \ldots$), such an explicitly discrete function represents in the form of a convenient (for special use) series, specifically, a decreasing geometric progression. This is what makes it possible to obtain directly the requisite working relations for the total masses of the iron impurities as a sum of the terms in this progression. They include a relation for calculating the total mass $m_{1\ldots\infty}$ of the iron impurities in the working specimen (for the number of operations $n = 1$ to $n \to \infty$, i.e., the mass actually separated and the remaining mass) as well as a relation for calculating the mass $m_{1\ldots n}$ of iron impurities separated for any bounded (finite) number n of operations [4, 5]:

$$m_{1\ldots\infty} = \frac{A}{\exp k - 1};$$
$$m_{1\ldots n} = \frac{A\,[1 - \exp(-kn)]}{\exp k - 1} < m_{1\ldots\infty}. \tag{2}$$

The mass m of the iron impurities separated from the feldspar specimen after each magnetic separation operation is presented in Fig. 1*a*. At first glance the curve obtained (see Fig. 1*a*) has the familiar form of a decreasing function tending to zero asymptotically in such cases [4, 5]. However, in the present case this function, in contrast to the analogous one for sand [4], turned out to have a different functional behavior. Thus, the characteristic obtained does not rectify in semi-logarithmic coordinates (see Fig. 1*b*). Hence, formally, it does not follow the function (1) and therefore lies outside the working model described here. More precisely, this function seems to rectify but in this case the rectification could be piecewise-linear with a 'kink' at $n = 4$.

The specific form of the dependence (m, n are the magnetic-control characteristics of the iron impurities in feldspar) shown in Fig. 1*b* is not an impediment to implementing

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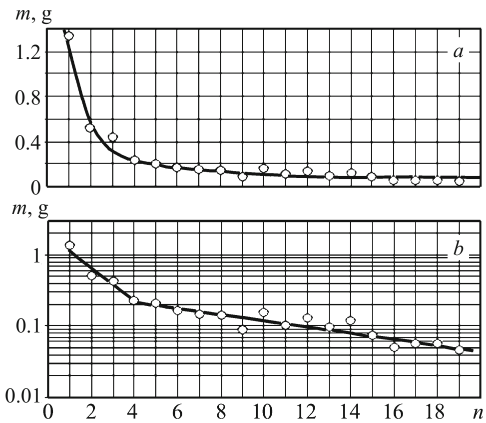

Fig. 1. Mass m of the iron impurities separated from feldspar versus the number n of magnetic-control operations: *a*) ordinary coordinates; *b*) semi-logarithmic coordinates.

the empirical-computational method of control described above, which simply requires adjustment.

Thus, the recommended working relations (1) and (2) can be easily adapted to both sections of the $m - n$ characteristic (see Fig. 1*b*). But we note that the steeply descending section of this characteristic contains a very limited amount of experimental data (only four points: m_1 , m_2 , m_3 and m_4 , where m_4 can be just as easily attached to the mildly sloping section). In contrast to the mildly sloping section it does not participate in any way in the subsequent computational extrapolation of the $m - n$ characteristic. Hence, it is possible to use a more practical variant of the calculation of the total mass $m_{1...\infty}$, viz., $m_{1...\infty} = m_1 + m_2 + m_3 + m_4 + m_{5...\infty}$.

In this variant the experimental values of the first four operating masses enter directly in the calculation. The total mass $m_{5...\infty}$ for the subsequent, including extrapolated, operations is determined by an additional calculation. This mass can be calculated using both relations (2) as follows:

$$m_{5...\infty} = m_{1...\infty} - m_{1...4} = \frac{A \exp(-kn)}{\exp k - 1} = \frac{A \exp(-k \times 4)}{\exp k - 1}, \quad (3)$$

where $m_{1...4}$ is the formal mass of the separated impurities, which would belong to the second, mildly sloping section if this section started at $n = 1$ and not $n = 5$.

Then, the working relation for this case becomes

$$m_{1...\infty} = m_1 + m_2 + m_3 + m_4 + \frac{A \exp(-k \times 4)}{\exp k - 1}. \quad (4)$$

Calculations performed with the relation using the direct experimental data m_1, m_2, m_3 and m_4 (see Fig. 1) and the obtained values $A = 0.34$ g and $k = 0.1$ give the mass of the iron impurities separated in this case from the feldspar $m_{1...\infty} = 4.68$ g. This value provides a basis for determining the mass fraction (concentration) of the iron impurities in a specimen of mass M: $c = m_{1...\infty}/M$. In the present case $c = 0.64\%$, which is more than a factor of 2 larger than the corresponding standard value (GOST 15045–78) and, needless to say, shows that a magnetic separator must be used to remove iron impurities from feldspar.

In summary, the proposed method of magnetic control makes it possible to determine the actual content of iron impurities in the raw materials being tested, even though there are cases where the operating mass relation for magnetic control is not an exponential function.

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